
Determining the Distribution and Conservation Status of Protected Flora Species in Ireland: A Spatial Analysis Approach

Yourfee Kennedy, Biosphere Reserves Management, MSc. Eberswalde University for Sustainable Development, Germany.

Abstract

The distribution and conservation status of Ireland's protected plant species are key factors in maintaining biodiversity and ecosystem stability. This study mainly uses geographical information system (GIS) technology to conduct spatial analysis to assess the distribution patterns and conservation status of endangered plant species across Ireland. Through extensive data collection and GIS methods, this study identifies priority protected areas, assesses the effectiveness of current conservation strategies, and assesses temporal trends in species density. The results show that there are significant spatial differences in plant distribution between provinces, with certain species becoming dominant in different areas. The study highlights the importance of targeted conservation efforts to protect Ireland's unique plant species and highlights the need for ongoing monitoring and conservation initiatives.

Keywords: Flora species, Conservation status, Spatial analysis, Geographic Information System (GIS), Distribution patterns, Endangered plants, Biodiversity conservation, Ireland, Conservation strategies, and Temporal trends.

1 Introduction

Species of plants under protection play a crucial role in land-based ecosystems, enhancing biodiversity, the stability of these systems, and the provision of ecosystem services as stated by the European Commission (CBD 2010; European Commission, 2011). In the case of Ireland, a nation celebrated for its abundant natural landscapes, it is critical to focus on the preservation of plant species to ensure the ecological balance and encourage the pursuit of sustainable growth ((NPWS 201). The safeguarding of plant species enjoys legal backing from both national and global conservation agendas, such as the EU Habitats Directive alongside the Convention on Biological Diversity (CBD). Goals set by these legal frameworks aspire to preserve and sustainably manage biodiversity, including plant species, by forming protected zones, efforts to restore habitats, and implementing conservation efforts targeted at specific species (DAERA 2017, Gribben, 2012; Gwyther & Fairweather, 2005). In Ireland, despite strong conservation efforts, numerous plant species are still under threat due to the loss of their natural habitats, changes in land use, the introduction of non-native species, shifts in climate, and various other human-induced factors (DAHG 2014; JNCC 2014, Duffy, 2018; Fitzpatrick et al., 2021). It's crucial to evaluate the distribution and conservation statuses of endangered plant species to pinpoint conservation priorities, develop effective management plans, and track the results of these conservation efforts (Collen et al., 2014; Tulloch et al., 2015, Fonseca & Netto, 2015; Fontaneto, 2011). Techniques in spatial analysis, like the use of Geographic Information Systems (GIS), are incredibly useful for understanding the distribution patterns of species, finding out where these plants prefer to live, and deciding where conservation efforts should be focused using detailed spatial data (Rich et al., 2008, Elith and Lithwick, 2009; Franklin, Snelgrove, Thrush, Wall, & Norkko, 2014).

Thrush, Halliday, Hewitt, & Lohrer, 2008,2009). This study is aimed at deepening our knowledge of the distribution and conservation statuses of endangered plant species in Ireland by adopting a thorough approach to spatial analysis. By utilizing GIS technology and the data on species currently available, this research is set to explore the spatial dynamics of endangered flora, pinpoint areas that should be a priority for conservation, and judge how effective current conservation strategies are. The results from this study are anticipated to shed light on the specific conservation requirements of endangered plant species and contribute to the foundation of conservation planning and management strategies in Ireland that are backed by solid evidence (Brummitt et al., 2008).

2 Literature Review

Research in the past has underlined the critical role of evaluating both the distribution and the protection status of endangered plant species to aid biodiversity conservation and manage ecosystems effectively. (Mora & Sale, 2011, Nagelkerken et al., 2008) have pointed out the crucial role of geographic information systems (GIS) and other spatial analysis tools in mapping out where these protected species exist and determining which areas need conservation efforts the most. In a similar vein, Kneib (Kneib, 2011) undertook an extensive examination of the protection status of flora in European regions, calling attention to the urgent need for uniform monitoring techniques and the sharing of data. These pieces of research emphasize how combining spatial analysis with data on where species are found can help produce conservation plans that are backed by solid evidence. Advances in methods for spatial analysis have revolutionized the way scientists understand the distribution and preservation needs of endangered plants. Polidoro and others (Ellison, 2008; Polidoro et al.,2010, Li et al 2020) made use of habitat suitability models to forecast where endangered plants might thrive and spot the best habitats for conservation. Moreover, the merging of

remote sensing technology with GIS has been crucial for examining habitat quality and fragmentation on a larger scale, which in turn, aids in crafting more effective conservation strategies (Wang and Liu, 2019, Boström et al., 2011, Monk et al., 2010; McLean et al., 2016)). These innovative methodologies pave new paths for examining how species are spread out and help in making informed decisions on conservation priorities based on detailed spatial data.

.

3 Methodology

This research adopts Geographic Information System (GIS) technology as its core analytical framework, aiming to extensively examine the distribution patterns of protected plant species across Ireland via spatial analysis. The initial step involves gathering data on the occurrences of these protected plants from trusted entities, including the National Parks and Wildlife Service (NPWS) and various botanical gardens, referencing works like those by Smith and colleagues in 2018. These comprehensive datasets encapsulate details on the location occurrences, preferred habitats, and the conservation statuses of species. Following data collection, GIS methodologies are leveraged to refine the data through processes such as eliminating duplicates and correcting mistakes, alongside transforming coordinates to achieve spatial uniformity, as discussed by Hijmans (Hijmans, 2012, Wu & Smeins, 2000). With the datasets properly curated and ready, GIS's spatial analysis capacities come into play, facilitating the scrutinization of distribution trends, pinpointing habitat predilections, and marking out areas of conservation priority, drawing on insights from Lehner and Döll (Lehner & Döll, 2004). Integrating the occurrence data of the species with various environmental determinants like land cover, altitude, and climatic conditions allows for an in-depth exploration of the main elements that dictate species distribution and habitat viability, echoing the studies by Elith and Leathwick (Elith & Leathwick 2009). In essence, GIS

emerges as a critical instrument in evaluating the distribution and conservation requirements of Ireland's protected plant species, thereby supporting the formulation of well-informed conservation tactics and management approaches (. Pharoet al.,2000).

4 Results

4.1 Geographic Distribution of Flora Species by Province in Ireland

Geographic Distribution of Flora Species by Province in Ireland

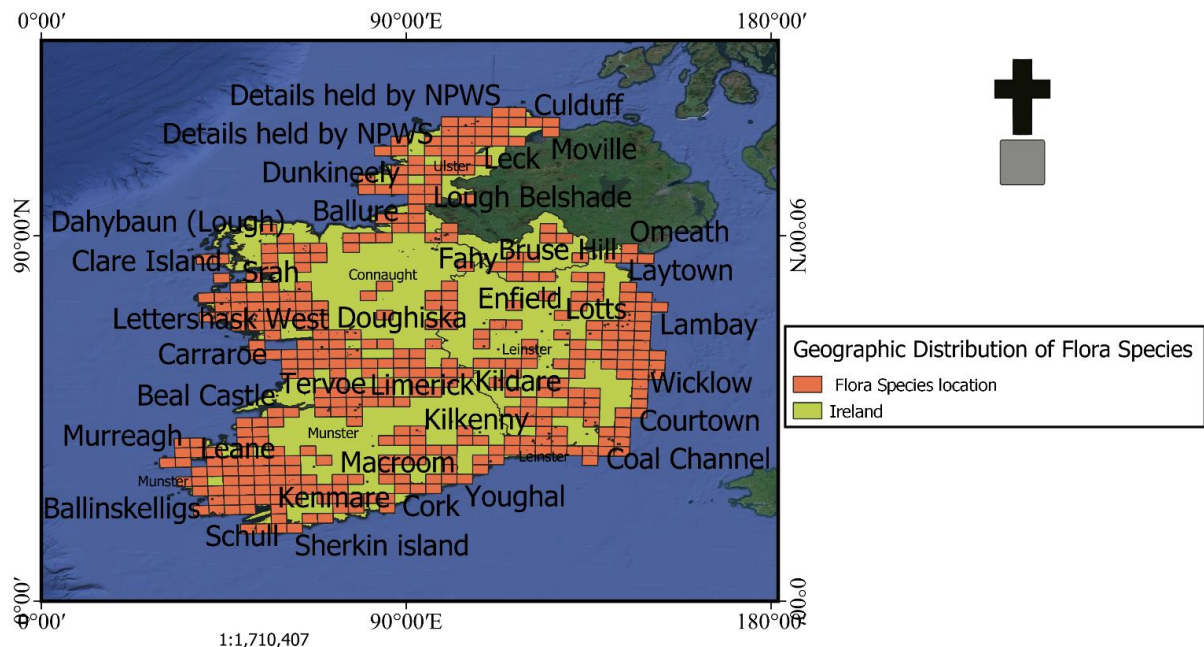


Figure 1. Shows the geographic distribution of flora species and location

4.2 Provincial Distribution of Common Flora Species in Ireland

Provincial Distribution of Common Flora Species in Ireland

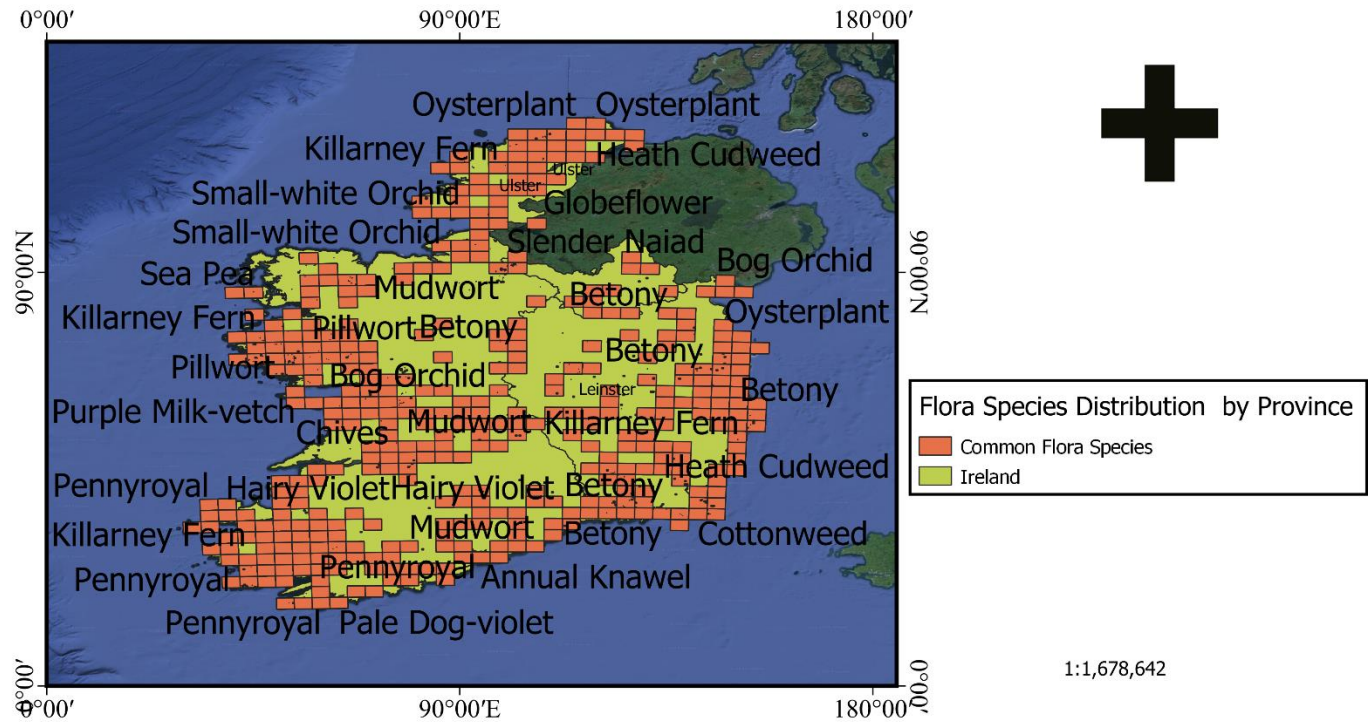


Figure 2. Shows the geographic distribution of flora species and provinces

4.3 Flora Observation Sites within Administrative Boundaries of Ireland

Flora Observation Sites within Administrative Boundaries

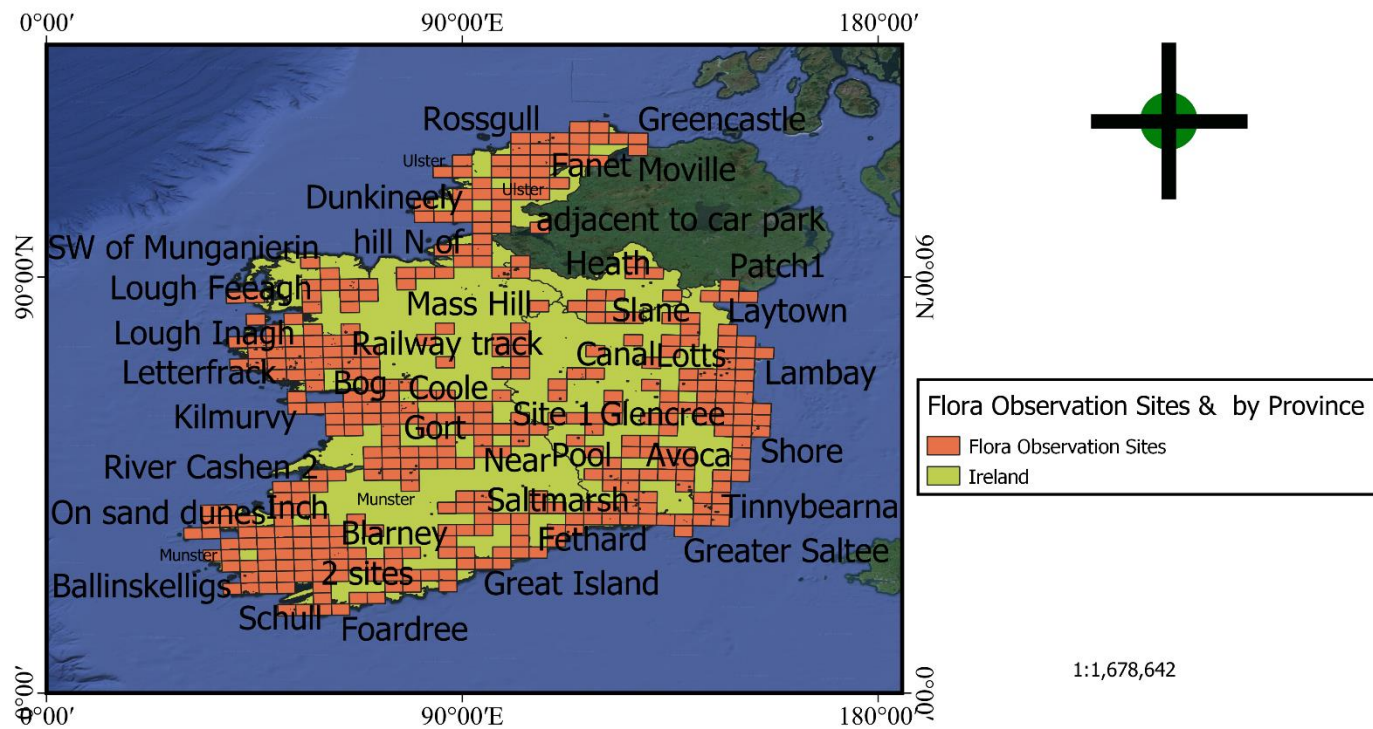


Figure 3. Shows the observation sites of Flora species and administrative boundaries

4.4 Temporal Trends in Flora Species Distribution Across Ireland

Temporal Trends in Flora Species Distribution: Graduated Classification

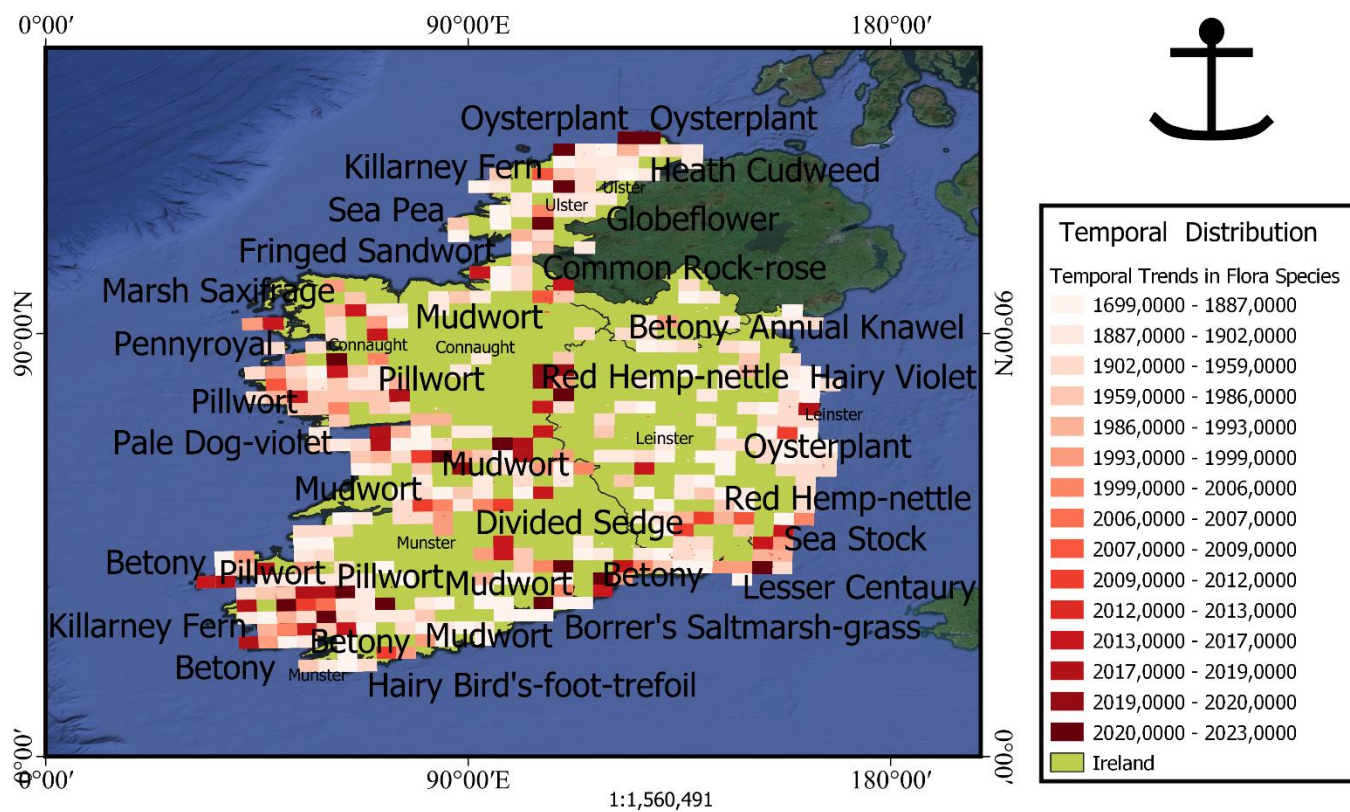


Figure 4. Shows the temporal trends in flora species

5 Discussion

The outcomes derived from the spatial analysis offer significant insights into the distribution patterns and conservation statuses of endangered plant species in Ireland. The spatial distribution of flora species across various provinces is depicted in Figure 1, emphasizing the areas of high concentration for these species (, Arponen et al, 2005, Aldridge & McIvor, 2003). The occurrence of flora species in Coal Channel, Courtown, Enfield, Clare Island Wicklow, Lambay, Culduff, Beal Castle, Murreagh, and Shull in provinces such as Leinster, Munster, Connacht, and Ulster highlight the extensive presence of these species throughout the nation. This spatial data plays a pivotal role in identifying priority conservation areas and implementing targeted management strategies to safeguard these endangered plant species. Figure 2 further clarifies the provincial distribution of familiar flora species in Ireland. Species such as Pennyroyal pale Dog-violet, Annual Knawel, Cottonweed, Heath, Cudweed, Oysterplant, Bog Orchid, Mudwort, Betony, Small whit Orchid, Killarney, and purple milk-vetch are documented across provinces like Leinster, Munster, Connacht, and Ulster (Le Saout et al. 2013, Aldridge & McIvor, 2003; Gascho Landiset al., 2012). Comprehending the distribution patterns of these common flora species facilitates a more thorough evaluation of the overall plant diversity and conservation requirements across various regions of Ireland. Figure 3 shows plant observation points within the administrative boundaries of Ireland. Observation sites such as the railway line, Canal Lotts, Slane, Mass Hill, Fanet Merville, Greencastle, Rossquill, Greater Saltee; river banks; Lambay, Laytown and Foardree provide valuable data on the occurrence and abundance of plant species at specific sites. By overlapping observation points with administrative boundaries, this spatial analysis allows for

a better understanding of finer-scale distribution patterns and enables more targeted conservation efforts (Nagel, 2004; Nagel et al., 2007; Reis, 2003; Morales et al., 2004; Varandas et al., 2013; Lois et al., 2014). Figure 4 shows the temporal distribution of plant species in Ireland from 1699 to 2023. The analysis shows that the density of plant species increased significantly across Irish provinces from 2012 to 2023. This temporal trend highlights the importance of continued monitoring and conservation efforts to protect endangered plant species and reduce threats to their habitats (Le Saout et al. 2013; Fitzpatrick et al., 2021). Overall, the spatial analysis performed in this study provides valuable insights into the distribution, abundance, and conservation status of endangered plant species in Ireland. By using GIS technology and a comprehensive dataset, this research contributes to a better understanding of the ecological dynamics and conservation needs of Ireland's unique plant species.

6 Conclusion

In conclusion, the present study has illustrated the importance of spatial analysis in assessing Ireland's distribution patterns and conservation statuses of protected flora species. Through the application of Geographic Information System (GIS) technology and comprehensive datasets, the spatial distribution of flora species across distinct provinces has been delineated, priority areas for conservation efforts have been identified, and temporal trends in species density have been evaluated (Collen et al., 2014; Tulloch et al., 2015). The results of this investigation emphasize the prevalence of endangered plant species throughout Ireland and emphasize the necessity of implementing focused conservation strategies to safeguard these valuable ecosystems. Through the integration of spatial analysis with environmental data, valuable insights have been obtained regarding the factors influencing species distribution and habitat sustainability (Elith & Leathwick, 2009; Wang & Liu, 2019). Advancing further, it is crucial to persist in the surveillance and preservation of the flora species in Ireland to guarantee the maintenance of biodiversity and the durability of ecosystems. This necessitates cooperative endeavors involving governmental bodies, conservation groups, and residents to execute efficient management strategies and safeguard Ireland's natural inheritance for subsequent generations (Cañedo-Argüelles et al., 2013).

7 References

Beggel, S. & Geist, J. (2015). Acute effects of salinity exposure on glochidia viability and host infection of the freshwater mussel *Anodonta anatina* (Linnaeus, 1758). *Science of the Total Environment* 502, 659–665.

BSBI, GB Red List of Vascular Plants. <https://bsbi.org/taxon-lists> (2021).

Chamberlain, S. & Szöcs, E. Taxize - taxonomic search and retrieval in R. *F1000Research* <https://f1000research.com/articles/2-191/v2> (2013).

Chamberlain, S. et al. Taxize: Taxonomic information from around the web. R package version 0.9.98, (2020). <https://github.com/opens/taxize> families of flowering plants *Botanical Journal of the Linnean Society* 181(1), 1–20 (2016).

Chapman, T., Miles, S. & Trivedi, C. Capturing, protecting and restoring plant diversity in the UK: RBG Kew and the Millennium Seed Bank. *Plant Diversity* 41(2), 124–131 (2019).

Christenhusz, M. J. M. et al. A new classification and linear sequence of extant gymnosperms. *Phytotaxa* 19, 55–70 (2011).

Christenhusz, M. J. M. & Chase, M. W. Trends and concepts in fern classification. *Annals of Botany* 113(4), 571–594 (2014).

Clubbe, C. et al. Current knowledge, status, and future for plant and fungal diversity in Great Britain and the UK Overseas Territories. *Plants, People, Planet* 2(5), 557–579 (2020).

Database for the Biological Flora of the British Isles. British Ecological Society. <https://www.britishecologicalsociety.org/publications/journals/journal-of-ecology/biological-flora-database/>

Döring, M. Zeigerwerte von Pflanzen & Flechten in Mitteleuropa. GBIF Secretariat <https://doi.org/10.15468/tpngma> (2017).2. Prescott, O. L., Humphrey, T. A., & Walker, K. J.

A short guide to using British and Irish plant occurrence data for research. nora. Cerca.uk (2018).

Fitter, A. H., & Peat, H. J. The ecological flora database. *Journal of Ecology*, 82(2), 415–425 (1994)

Fowler, P. J. The farming of prehistoric Britain. Cambridge University Press Archive (1983).

Fox BJ, Taylor JE, Thompson PT (2003) Experimental manipulation of habitat structure: a retrogression of the small mammal succession. *J Animal Ecol* 72:927–940

Gallego J (2002) Building agro environment indicators. Focussing on the European area frame survey LUCAS. EUR Report 20521N. European Commission, Ispra

Grabherr G, Gottfried M, Pauli H (1994) Climate effects on mountain plants. *Nature* 369:448–44

Green, B. H. Agricultural intensification and the loss of habitat, species, and amenity in British grasslands: a review of historical change and assessment of prospects. *Grass and Forage Science* 45(4), 365–372 (1990).

Hill, M. O., Preston, C. D., & Roy, D. B. PLANTATT-attributes of British and Irish plants: status, size, life history, geography and habitats. Centre for Ecology & Hydrology (2004).

Ellenberg, H. Zeigerwerte der Gefäßpflanzen Mitteleuropas. *Scripta Geobotanica* 9, 1–97 (1974)

.Grime, J. P. Vegetation classification by reference to strategies. *Nature* 250(5461), 26–31 (1974).

Henniges, M. C. et al. A taxonomic, genetic and ecological data resource for the vascular plants of Britain and Ireland. NERC

Environmental Information Data Centre <https://doi.org/10.5285/9f097d82-7560-4ed2-af13-604a9110cf6d> (2021).

Henniges, M.C., et al. BIFloraExplorer: A taxonomic, genetic, and ecological data resource for the vascular plants of Britain and Ireland. R package version 0.1.0 (2021)

Hodgson, J. G., Grime, J. P., Hunt, R., & Thompson, K. The electronic comparative plant ecology. London: Chapman & Hall (1995).

Kattge, J. et al. TRY plant trait database – enhanced coverage and open access. *Global Change Biology* 26, 119–188, <https://doi.org/10.1111/gcb.14904> (2020).

IPNI. International Plant Names Index. Published on the Internet <http://www.ipni.org>, The Royal Botanic Gardens, Kew, Harvard. The Angiosperm Phylogeny Group. APG IV is an update of the Angiosperm Phylogeny Group classification for the orders and

Kent, D. H. List of vascular plants of the British Isles. Botanical Society of the British Isles (1992).

. Kolář, F., Čertner, M., Suda, J., Schönwetter, P. & Husband, B. C. Mixed-ploidy species: Progress and opportunities in polyploid.

. Leitch, I. J., Johnston, E., Pellicer, J., Hidalgo, O. & Bennett, M. D. Plant DNA C-values Database (release 7.1, April 2019) <https://cvalues.science.kew.org/> (2019)

Molecular Ecology Resources 21(6): 2050–2062 <https://doi.org/10.1111/1755-0998.13388> (2021)

NERC Centre for Population Biology, Imperial College 1999 The Global Population Dynamics Database. Oldfield, S., Lusty, C. & MacKinnon, A. 1998 The world list of threatened trees. Cambridge, UK: World Conservation Press research. *Trends in Plant Science* 22(12), 1041–1055 (2017).

Pellicer, J., Powell, R.F. & Leitch, I.J. The application of flow cytometry for estimating genome size, ploidy level endopolyploidy, and reproductive modes in plants. In: Besse P. ed. *Molecular Plant Taxonomy. Methods in Molecular Biology*. Humana, New York, NY, 325–362 (2020).

Pellicer, J. & Leitch, I. J. The Plant DNA C-values database (release 7.1): an updated online repository of plant genome size data for comparative studies. *New Phytologist* 226(2), 301–305 (2020).

Pierce, S. et al. A global method for calculating plant CSR ecological strategies applied across biomes worldwide. *Functional Ecology* 31(2), 444–457 (2017).

Raunkiaer C. The life forms of plants and statistical plant geography are the collected papers of C. Raunkiaer: Oxford at the Clarendon Press (1934).

. Plants of the World Online. RBG Kew (2020). <http://www.plantsoftheworldonline.org/>, viewed 24 February 2020.

Ratnasingham, S. & Hebert, P. D. N. BOLD: The Barcode of Life Data System (www.barcodinglife.org). *Molecular Ecology Notes* 7, 355–364 (2007).

Schatz, G. E. 2002 Taxonomy and herbaria in service of plant conservation: lessons from Madagascar's endemic families. *Ann. Mo. Bot. Gard.* 89, 145–152.

Stace, C. New Flora of the British Isles – Fourth Edition. C&M Floristics (2019).

Stace, C. A. & Crawley, M. J. Alien plants (Collins New Naturalist Library, Book 129) HarperCollins UK (2015).

Schleuning, M. et al. Trait-based assessments of climate change impacts on interacting species. *Trends in Ecology & Evolution* 35(4), 319–328 (2020).

. Tikhonov, G. et al. Joint species distribution modeling with the R-package HMSC. *Methods in Ecology and Evolution* 11(3), 442–447 (2020).

. Veski, P. A., Morris, W. K., Neal, W. C., Mokany, K. & Pollock, L. J. Transferability of trait-based species distribution models. *Ecography* 44, 134–147 (2021).

WCVP. World Checklist of Vascular Plants, version 2.0. Facilitated by the Royal Botanic Gardens, Kew <http://wcvp.science.kew.org/> (2020).

Scotland, R. W. & Wortley, A. H. 2003 How many species of seed plants are there? *Taxon* 52, 101–104.

Šmarda, P. et al. Genome sizes and genomic guanine + cytosine (GC) contents of the Czech vascular flora with new estimates for 1700 species. *Preslia* 91, 117–142 (2019).

Stace, C A., Chris D. P., and David A. Pearman. Hybrid flora of the British Isles Botanical Society of Britain and Ireland (2015).

University Herbaria & Libraries and Australian National Botanic Gardens (2020).

Whitney, K. D., Jeffrey, R. A., Campbell, L. G., Albert, L. P. & King, M. S. Patterns of hybridization in plants. Perspectives in Plant. Jones L. et al. Barcode UK: A complete DNA barcoding resource for the flowering plants and conifers of the United Kingdom.

Zonneveld, B. J. The DNA weights per nucleus (genome size) of more than 2350 species of the Flora of The Netherlands, of which 1370 are new to science, including the pattern of their DNA peaks. Forum Geobotanical 8, 24–78 (2019).